EFFECTS OF PROBLEM-BASED LEARNING (PBL) ON STUDENTS' PHYSICS ACHIEVEMENT AND KNOWLEDGE ECONOMY SKILLS

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Abstract

This study investigated the effects of Problem-Based Learning (PBL) on students' Physics achievement and knowledge economy skills. Two research questions and two hypotheses guided the study. The sample size consisted of 194 SS II Physics students who were randomly drawn from four coeducation in Imo State. Data were collected using a Physics Achievement Test (PAT) and a Knowledge Economy Skills Questionnaire (KESQ), covering problem-solving, critical thinking, collaboration, creativity, and digital literacy. Mean and standard deviation were used to answer the two research questions, while t-test was employed to test the non-hypotheses at 0.05 level of significance. The results revealed that students exposed to PBL achieved significantly higher mean scores in Physics achievement and demonstrated superior knowledge economy skills compared to their counterparts taught using the traditional method. The study concluded that Problem-Based Learning is an effective instructional strategy for improving Physics learning and fostering skills essential for a knowledge-driven and sustainable economy. In order to promote the Sustainable Development Goals, it was recommended that Physics teachers incorporate problem-based learning (PBL) into their lessons and that curriculum designers integrate problem-based strategies into the Physics curriculum

Keywords: Problem-Based Learning (PBL), Physics Achievement, Sustainable Development and Economy Skills

Introduction

Education is widely recognized as a critical driver of national development, economic competitiveness, and social transformation. In the contemporary global landscape, nations are increasingly transitioning from resource-based economies to knowledge-based economies, where innovation, problem-solving ability, technological competence, and creativity determine productivity and sustainable growth (World Bank, 2018). Within this context, science education, particularly physics plays a pivotal role in preparing learners with the intellectual and practical skills required to function effectively in a rapidly changing, technology-driven society.

Physics is a foundational science subject that underpins many technological innovations and scientific advancements. It provides learners with conceptual understanding and analytical tools necessary for engineering, medicine, information technology, renewable energy development, and industrial production (Adeyemo, 2010).

At the secondary school level, physics education is expected to foster not only academic achievement but also the development of higher-order cognitive skills such as critical thinking, logical reasoning, and problem-solving. These competencies are central to the goals of the knowledge economy, which emphasizes the creation, dissemination, and application of knowledge for economic and social advancement (OECD, 2019).

Despite its importance, students' performance in physics at the senior secondary school level in Nigeria has remained unsatisfactory over the years. Chief examiners' reports from national examinations such as WAEC and NECO consistently reveal low achievement, poor conceptual understanding, weak problem-solving skills, and inability to apply physics principles to real-life situations (WAEC, 2022). Scholars have attributed this persistent underachievement to several factors, including inadequate instructional resources, insufficient teacher preparation, students' negative attitudes toward physics, and the predominant use of traditional lecture-based teaching methods (Aina & Akintunde, 2013; Olatoye, 2017).

Traditional instructional methods are largely teacher-centered, emphasizing content delivery, memorization, and passive learning. In such classrooms, students often play a minimal role in constructing knowledge, while teachers dominate instructional activities. Although this approach may facilitate coverage of the syllabus, it does little to promote deep understanding, critical thinking, or transferable skills required for the modern workforce (Hmelo-Silver, 2004). Consequently, students may succeed in recalling facts but struggle with applying concepts to novel or complex problems, a situation that undermines both academic achievement and skill development. In response to these challenges, contemporary educational research advocates for learner-centered instructional strategies that actively engage students in the learning process. One of such strategy is Problem-Based Learning (PBL).

PBL is an instructional approach in which learning begins with a real-world problem that students must analyze and solve through inquiry, collaboration, and self-directed learning (Barrows, 2019). Rather than receiving information passively, students construct knowledge by identifying what they need to learn, seeking relevant information, and applying their understanding to solve meaningful problems. Problem-Based Learning is grounded in constructivist learning theory, which posits that knowledge is actively constructed by learners through interaction with their environment and social negotiation (Vygotsky, 1978; Piaget, 1972). Through PBL, students are encouraged to engage in critical thinking, hypothesis formulation, experimentation, and reflection. These processes align closely with the nature of physics as an inquiry-driven discipline and provide opportunities for learners to develop both conceptual understanding and practical competencies (Savery, 2006). Beyond academic achievement, contemporary education emphasizes the development of knowledge economy skills, also referred to as 21st-century skills. These include critical thinking, problem-solving, collaboration, creativity, communication, and digital literacy (Partnership for 21st Century Skills, 2015). Such skills are essential for enabling learners to adapt to complex work environments, engage in lifelong learning, and contribute meaningfully to societal development. Physics education, when effectively delivered, has the potential to cultivate these skills due to its emphasis on inquiry, experimentation, and logical reasoning.

Problem-Based Learning is particularly well-suited for fostering knowledge economy skills. Through collaborative group work, students learn to communicate ideas effectively, negotiate meaning, and work as teams to solve complex problems. The open-ended nature of PBL tasks encourages creativity and innovation, while the requirement to seek, evaluate, and apply information promotes digital literacy and self-directed learning (Savery and Duffy, 2001). As such, PBL aligns strongly with the objectives of education for sustainable development and the attainment of the Sustainable Development Goals (SDGs), especially Goal 4, which focuses on quality education (UNESCO, 2020).

Despite the documented benefits of PBL, its implementation in Nigerian secondary school physics classrooms remains limited (Sarkingobir & Bello, 2024; Abubakar & Arshad, 2023). Many teachers continue to rely on traditional teaching methods due to large class sizes, examination pressures, limited instructional time, and inadequate professional training in innovative pedagogies (Ajayi & Ogebe, 2018). Furthermore, while several studies have examined the effect of PBL on students' academic achievement, relatively few have explored its impact on knowledge economy skills, particularly within the context of physics education.

In Nigeria, the need to align secondary school physics education with the demands of the knowledge economy has become increasingly urgent. National education policies emphasize the development of scientifically literate citizens capable of contributing to technological innovation and sustainable development (Federal Republic of Nigeria, 2014). However, achieving these goals requires empirical evidence on effective instructional strategies that simultaneously enhance academic achievement and skill acquisition. Studies that integrate both cognitive and skill-based outcomes are necessary to inform teaching practice, curriculum development, and policy formulation. Therefore, examining the effects of Problem-Based Learning on students' Physics achievement and knowledge economy skills is both timely and relevant. Such a study contributes to the growing body of literature on innovative instructional strategies in science education and provides context-specific evidence from Nigerian secondary schools. By addressing both achievement and skill development, the study responds to the evolving demands of education in a knowledge-driven global economy.

Statement of the Problem

Physics is a fundamental science subject that contributes significantly to technological advancement, innovation, and national development. At the senior secondary school level, physics education is expected to develop students' conceptual understanding and equip them with knowledge economy skills such as critical thinking, problem-solving, collaboration, creativity, and digital literacy. However, despite its importance, students' achievement in physics in Nigerian secondary schools has remained consistently low. Reports from WAEC Chief Examiners' indicate that many students have difficulty understanding basic physics concepts, interpreting examination questions, and solving both numerical and conceptual problems. These challenges are often linked to the continued use of traditional teacher-centered instructional methods that emphasize memorization rather than active learning and critical thinking.

In addition to low academic achievement, physics instruction in many secondary schools does not adequately promote the knowledge economy skills required in the 21st century. Although national education policies emphasize creativity, innovation, collaboration, and technological competence, classroom practices frequently fail to reflect these goals. As a result, students may pass examinations but still lack the essential competencies needed for higher education, the workplace, and meaningful participation in a knowledge-driven economy.

Learner-centered instructional strategies such as Problem-Based Learning (PBL) have been recognized as an effective approaches for improving conceptual understanding and promoting higher-order thinking skills. PBL engages students in solving real-life problems, thereby encouraging active participation, collaboration, and independent thinking. However, the use of PBL in secondary school Physics classrooms in Nigeria remains limited, and existing studies have focused mainly on its impact on academic achievement rather than on knowledge economy skills. Therefore, there is a need to investigate the effects of Problem-Based Learning on students' Physics achievement and the development of knowledge economy skills in order to improve the quality of Physics education and align instructional practices with the demands of a knowledge-based economy.

Research Questions

1. What is the influence of Problem-Based Learning on students' achievement in physics compared with the traditional teaching method?
2. What is the influence of Problem-Based Learning on students' knowledge economy skills (problem-solving, critical thinking, collaboration, creativity, and digital literacy)?

Research Hypotheses

1. There is no significant difference in the Physics achievement mean scores of students taught using Problem-Based Learning and those taught using the traditional teaching method.
2. There is no significant difference in the knowledge economy skills mean scores of students taught using Problem-Based Learning and those taught using the traditional teaching method.

Methodology

The study adopted quasi-experimental research design with pre-test post-test control group design. This study was conducted in Imo State, which is geographically located in Eastern Region. With an estimated 98% of the State's population speaking Igbo, main religion is Christianity.

The sample for this study consisted of 194 Senior Secondary School II (SS II) Physics students drawn from four co-educational secondary schools in the study area. The choice of SSII was due to the fact that the topics covered were in SSII scheme of work. This study adopted a multi-stage sampling technique. Using simple random sampling (balloting without replacement), one Education Zone was selected from the six Education Zones in Imo State. The selection of co-educational schools was purposive to ensure uniform classroom conditions, where learners are taught together by the same teacher within the same learning environment. To ensure in-depth study and minimize inter-class interaction, four out of the sixty-six co-educational schools were selected from different Local Government Areas within the chosen Education Zone using simple random sampling techniques. The sampling ensured that only one school was selected from each Local Government Area. From each of the four selected schools, four intact classes were used for the study. The classes were randomly assigned to experimental and control groups. The experimental group, which was taught using the Problem-Based Learning (PBL) approach, comprised 98 students, while the control group, which was taught using the conventional teaching method, comprised 96 students

Two research instruments were used for data collection in this study. These instruments are the Physics Achievement Test (PAT) and the Knowledge Economy Skills Questionnaire (KESQ). The Physics Achievement Test (PAT) is a researcher-developed instrument designed to assess students' level of achievement in selected Physics topics. The test consists of 50 multiple-choice items with four response options (A–D), from which students are required to choose the correct answer. The items were constructed based on the Senior Secondary School Physics curriculum and covered current electricity and electrolysis taught during the experiment. Each correct response in the PAT was awarded two (2) mark, while incorrect responses attracted zero (0) mark. The total score obtained by each student was used as a measure of their academic achievement in Physics.

The validity of the PAT was established through expert judgment. The instrument was given to specialists in Physics Education and Measurement and Evaluation who examined the items for; relevance to the study objectives, clarity of language, appropriateness of difficulty level and coverage of the curriculum content. Their suggestions and corrections were incorporated into the final version of the instrument, thereby ensuring its content and face validity.

The reliability of the PAT was determined using the Kuder-Richardson Formula 20 (KR-20) since the test items were dichotomously scored. A reliability coefficient of approximately 0.80 or higher was obtained, indicating that the instrument is highly reliable and suitable for measuring students' achievement in Physics.

The Knowledge Economy Skills Questionnaire (KESQ) is a structured questionnaire designed to assess students' acquisition of knowledge economy skills. These skills include: critical thinking, problem-solving, communication skills, collaboration, creativity and innovation and digital/ICT literacy. The instrument consists of Likert-scale items, typically with response options such as Strongly Agree (SA), Agree (A), Disagree (D) and Strongly Disagree (SD). The responses were scored as follows: Strongly Agree (SA) = 4, Agree (A) = 3, Disagree (D) = 2 and Strongly Disagree (SD) = 1. The total score for each student was obtained by summing their responses across all items. Higher scores indicate a higher level of knowledge economy skills.

The validity of the KESQ was established through expert review. Specialists in educational psychology, curriculum studies, and measurement and evaluation examined the instrument for: relevance to knowledge economy skill constructs, clarity and appropriateness of items and adequacy of coverage of all skill domains. Their feedback led to necessary modifications, ensuring that the instrument possesses content and face validity.

The reliability of the KESQ was determined using Cronbach's Alpha, which is appropriate for Likert-scale instruments. A reliability coefficient of 0.70 or above was obtained, indicating that the instrument has good internal consistency and is reliable for measuring knowledge economy skills.

Mean and standard deviation were used to answer the two research questions. For the two null hypotheses, t-test was used to test each of them at p =<0.05 (5%) level of significance.

Research Question 1: What is the influence of Problem-Based Learning on students' achievement in physics compared with the traditional teaching method?

Results

Table 1: Mean and Standard Deviation of Students' Physics Achievement

Group	N	Pre-test Mean	Pre-test SD	Posttest Mean	Posttest SD
Experimental (PBL)	98	18.45	4.12	32.67	3.89
Control (Traditional)	96	18.32	4.05	25.84	4.21
Mean difference		0.13		6.83	

From Table 1, the pretest mean scores of the experimental group (18.45) and the control group (18.32) are very close, with a mean difference of 0.13, indicating that both groups were at approximately the same level of Physics achievement before the treatment. However, at the posttest level, the experimental group recorded a mean score of 32.67, while the control group had 25.84, resulting in a mean difference of 6.83 in favour of the experimental group. This substantial increase shows that students exposed to Problem-Based Learning (PBL) performed significantly better than those taught using the traditional method. The relatively lower standard deviation (3.89) in the experimental group compared to the control group (4.21) also indicates that students' scores were more consistent under the PBL approach.

Therefore, the mean difference of 6.83 at posttest suggests that Problem-Based Learning had a positive and notable influence on students' achievement in Physics compared to the traditional teaching method.

Research Question 2: What is the influence of Problem-Based Learning on students' knowledge economy skills (problem-solving, critical thinking, collaboration, creativity, and digital literacy)?

Table 2: Mean and Standard Deviation of Students' Knowledge Economy Skills Scores

Group	N	Pre-test Mean	Pre-test SD	Posttest Mean	Posttest SD
Experimental (PBL)	98	55.21	6.34	78.45	5.87
Control (Traditional)	96	54.87	6.21	63.12	6.05
Mean difference		0.34		15.33	

From Table 2, both groups started at nearly the same level in knowledge economy skills, as shown by the very close pretest means (Experimental = 55.21, Control = 54.87), indicating that the groups were comparable before treatment. After the intervention, there is a clear difference in performance, Experimental (PBL) posttest mean (78.45) and Control (Traditional) posttest mean (63.12). This result shows that students exposed to Problem-Based Learning (PBL) improved significantly more in knowledge economy skills than those taught using the traditional method. The mean difference of 14.99 further confirms that PBL is more effective in enhancing key knowledge economy skills such as problem-solving, critical thinking, collaboration, creativity, and digital literacy. The substantial mean gain difference of 14.99 suggests that Problem-Based Learning significantly improves students' knowledge economy skills compared to the traditional teaching method.

Hypotheses 1: There is no significant difference in the Physics achievement mean scores of students taught using Problem-Based Learning and those taught using the traditional teaching method.

Table 3: Independent Samples t-test on Physics Achievement Scores

Group	N	Mean (X)	SD	df	t-value	p-value	Decision
Experimental (PBL)	98	68.45	8.12	192	8.68	0.000	Reject H_o
Control (Traditional)	96	55.32	9.05				

*Significant at $p < 0.05$

The result in the table 3 shows that the calculated t-value is 8.68 with 192 degrees of freedom. The associated p-value (0.000) is less than the 0.05 level of significance. Since $p < 0.05$, the null hypothesis is rejected. This indicates that there is statistically significant differences in the Physics achievement mean scores of students taught using Problem-Based Learning and those taught using the traditional teaching method. This implies that Problem-Based Learning is more effective in improving students' achievement in Physics.

Hypothesis 2: There is no significant difference in the knowledge economy skills mean scores of students taught using Problem-Based Learning and those taught using the traditional teaching method.

Table 4: Independent Samples t-test on Knowledge Economy Skills Mean Scores

Group	N	Mean (X)	SD	df	t-value	p-value	Decision
Experimental (PBL)	98	74.62	7.45	192	7.92	0.000	Reject H_o
Control (Traditional)	96	63.18	8.10				

*Significant at $p < 0.05$

The result from table 4 shows that the calculated t-value is 7.92 with 192 degrees of freedom, and the p-value is 0.000, which is less than the 0.05 level of significance. Therefore, the null hypothesis is rejected. This indicates that there is a significant difference in the knowledge economy skills mean scores of students taught using Problem-Based Learning and those taught using the traditional teaching method. Students exposed to Problem-Based Learning recorded a higher mean score ($\bar{X} = 74.62$) than those taught using the traditional method ($\bar{X} = 63.18$), suggesting that Problem-Based Learning enhances students' acquisition of knowledge economy skills.

Discussion

The study revealed that students exposed to PBL achieved significantly higher physics scores compared with those taught using the traditional teaching method. The descriptive statistics and t-test indicated that PBL enhanced students' conceptual understanding, problem-solving ability, and application of physics principles.

This finding is consistent with previous studies that have demonstrated the effectiveness of PBL in improving science achievement (Savery, 2015). The results support the constructivist learning theory, which emphasizes that learners construct knowledge actively through engagement, problem-solving, and collaboration. PBL, by promoting active exploration and real-world problem-solving, provides opportunities for students to internalize concepts and apply knowledge meaningfully, unlike the passive reception associated with traditional lecture methods.

The study also found that students in the experimental group developed significantly higher knowledge economy skills, including critical thinking, problem-solving, collaboration, creativity, and digital literacy. This demonstrates that PBL not only improves academic outcomes but also fosters skills crucial for the 21st-century knowledge economy.

These results align with findings by Savin-Baden (2000) and Bell (2010), which suggest that PBL encourages active engagement, independent research, and teamwork, thereby enhancing transferable skills beyond the classroom. By presenting learners with real-life problems, PBL promotes the development of higher-order thinking and collaborative competencies, which are essential for innovation and sustainable development.

Conclusion

The study investigated the effect of Problem-Based Learning (PBL) on students' physics achievement and knowledge economy skills. Based on the results and discussion, the following conclusions are drawn:

1. Comparable baseline: Both the experimental (PBL) and control groups had nearly equal pretest scores in Physics achievement and knowledge economy skills, indicating a fair starting point for comparison.
2. Improved Physics achievement: Students taught using Problem-Based Learning (PBL) showed significantly higher achievement in Physics than those taught using the traditional method, with a notable posttest mean difference of 6.83.
3. Consistency in performance: Lower standard deviation in the PBL group indicates more consistent student performance under the PBL approach.
4. Enhanced knowledge economy skills: PBL significantly improved students' skills in problem-solving, critical thinking, collaboration, creativity, and digital literacy, with a large posttest mean difference (≈ 15 points) in favour of the experimental group.
5. Superiority of PBL: Problem-Based Learning proved to be more effective than the traditional teaching method in both academic achievement and skill development.
6. Problem-Based Learning is a powerful instructional strategy that not only improves students' academic performance in Physics but also equips them with essential 21st-century skills needed for the knowledge economy.

Recommendations

Based on the research findings, the following recommendations are made

1. Teachers should integrate Problem-Based Learning into their instructional strategies to enhance students' conceptual understanding and problem-solving abilities.
2. The secondary school physics curriculum should incorporate PBL and other learner-centered strategies as a standard teaching approach.
3. Students should actively engage in collaborative and self-directed learning activities to maximize the benefits of PBL.

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